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Blowing the Wind Energy in Indonesia

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Abstract

Wind power generation is no longer a new issue in the world. However, the market in Indonesia is remaining "un-developed". Barriers had been identified. One of the main constraints is the low of confident level on the wind availability itself. So many researches had been conducted, however up to present the installed capacity of wind power generation is only around 1.6 MW out of 9.29GW total capacity predicted.

Hence, an intensive promotional program should be conducted to promote wind power generation as an alternative for a more sustainable energy. "Commitment" is all what it takes to save the future's energy.

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Keywords: wind; renewable energy; power generation; sustainability; WHyPGen; hybrid; Indonesia

Nomenclature

BMKG	Badan Meteorologi, Klimatologi dan Geofisika (Indonesian Agency for Meteorology, Climatology and Geophysics)
DIY	Daerah Istimewa Yogyakarta
DKI Jakarta	Daerah Khusus Ibukota Jakarta
EVN	Electricity of Vietnam Group
GW	Gigawatt
GWh	Gigawatt hour
GWEA	Global Wind Energy Association

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kW	Killowatt
LAPAN	Lembaga Penerbangan dan Antariksa Nasional (National Institute of Aeronautics and Space)
m/s	meter per second
MEMR	Ministry of Energy and Mineral Resources
MW	Megawatt
NTT	Nusa Tenggara Timur (East Nusa Tenggara)
PLN	Perusahaan Listrik Negara (State Electricity Company)
WECS	Wind Energy Conversion System
WHyPGen	Wind Hybrid Power Generation
WRA	Wind Resources Assessment

1. Introduction

1.1 Background

Indonesia is the world's largest archipelago, which consist of more than 17,000 islands and only about 5,700 islands is inhabited. Indonesia coastal line is more than 81,000 km. The characteristics of small island is poor for resources such as limited freshwater and electricity supply. To built the installation of freshwater and electricity are very expensive and the maintenance and operation are difficult. Beside that, the energy consumption is still dominated by the costly of fossil fuel. However the energy consumption is growing as the increased number of the population. The fossil fuel demand increases continuously, while the oil resources are depleting which caused fuel shortage in many islands. This can effects the continuity of electricity supply for the people, which then raise burden and lead to a high economical cost of the supply.

Wind energy as a one of renewable energy is clean and free for all, however, its kinetic potential energy should change to fulfill the need energy consumption by using Wind Energy Conversion System (WECS) to generate electricity or other mechanical energy such for pumping system. Tor realize these, many activity related to wind energy should be done as wind data resources assessment, research and development (R and D) on wind turbine technology and also introducing and disseminating of using wind energy at several site selection with good enough wind velocity.

The objective of wind energy development and utilization in Indonesia is to establish a wind energy power generation system as part of the rural electrifications program at various rural and isolated areas in Indonesia, by developing the capability and mastering the science and technology of WECS, the utilizations and dissemination of technology through private sector and local manufacture supports.

1.2 Utilization of wind energy world wide

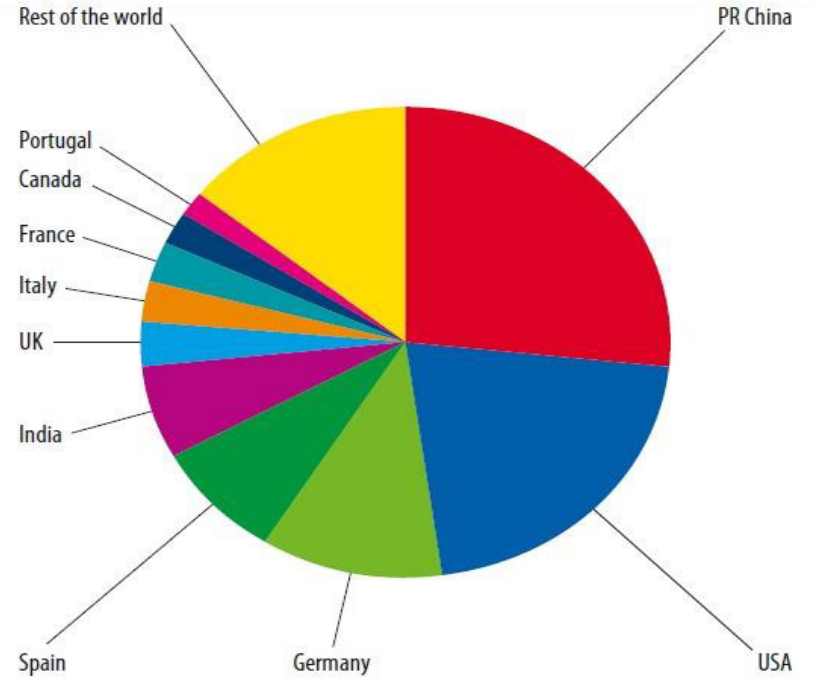
Compare to 2011, the global wind power market grew more than 10% in 2012, and nearly 45 GW is a new wind power plant. The total of wind power plant at the end of 2012 was 282.5 GW, representing cumulative market growth of more than 19%. It is an excellent growth rate, even though it is lower than the annual average growth rate over the last 10 years of about 22% [1].

At the end of 2011, the expectations for wind power market growth were uncertain, as the economic slowdown continues in Europe and the political uncertainty in the US made it difficult to make projections for 2012. Nevertheless, 2012 turned to be a great year for wind power installations in the traditional markets of North America and Europe.

Conversely, China the largest market for wind since 2009 showed a slower market development, which meant that the US regained the top spot in 2012. Market consolidation and rationalisation in China, and a lapse in policy in India were the main reasons for the significant slowdown in Asia in 2012, but these conditions are expected to be short-lived, and Asian dominance of global wind markets is expected to continue. Canada, Brazil and Mexico are expected to have strong years in 2013, and a few hundred megawatts from sub-Saharan Africa will come online for the first time: in South Africa, Ethiopia and possibly Kenya; and global installations will be further augmented by new projects coming on line in Mongolia, Pakistan, the Philippines and Thailand. In Figure 1 and Table 1 show 10

biggest countries in cumulative installed capacity of wind turbine.

Based on the Global Wind Energy Association (GWEA), China has the biggest wind power generation market in the world with the total of 75.3 GW or equal with 26.7% from the total world market. In the second place, is USA with the total wind power generation installed capacity of 60.007 GW, which took the share of the world total wind energy market about 21.2%. And in the third place is German with the total capacity of wind power generation installed is 31.308 GW or equal with 11.1% of the world wind energy market [2].



Source : GWEC 2013.

Fig. 1. Top 10 country wind power utilization.

Table 1. Top 10 country wind power utilization.

No	Country	Installed Capacity (GW)	Share (%)
1	PR China	75.,3	26.7
2	USA	60.007	21.2
3	Germany	31.308	11.1
4	Spain	22.796	8.1
5	India	18.421	6.5
6	UK	8,445	3.0
7	Italy	8.144	2.9
8	France	7.564	2.7
9	Canada	6.200	2.2
10	Portugal	4.525	1.6
11	Rest of the world	39.853	14.1
12	Total TOP 10	242.734	85.9
13	World Total	282.587	100.0

1.3 Wind power at South East Asia

Some of the region's countries are taking measures to encourage wind-power development, but regulatory and economic uncertainty and poor transmission are holding back progress in the Philippines, which has just a single 33 MW wind farm built in 2009. While in Thailand, the total capacity installed of wind power generation is 7 MW, in which the addition of 2 MW has just been added last year. This 7 MW wind power installed capacity will soon be boosted with the plan of developing four wind farm with the total of 242 MW. As the start, 2x90 MW of wind farms will be developed at Nakhon Ratchasima this year using Siemens turbines, and called the Huay Bong II and III. While the construction of the 90 MW at Thep Sathit Fars had been delayed indefinitely due to government disagreeing on the locations. In Thailand, sites with the best wind potential are often located in the state-owned conservation areas, which make the land permission become more complex. Nevertheless, wind projects totaling 645 MW are in the Thailand's pipeline development [3].

In Vietnam, the application of on-grid wind-power generation is targeted to reach 1GW by 2020 and 6.2 GW by 2030. This had been placed under Vietnam's Power Master Plan VII which introduced last year, and the obligation on Electricity of Vietnam Group (EVN) to purchase all electricity generated by on-grid wind plants.

Studies have estimated that Vietnam has good wind energy potency. The study conducted by the World Bank showed that Vietnam's wind energy potency is about 521GW. While the study conducted by the EVN stated that Vietnam has the potency of wind energy about 1,785GW [3].

According to GIZ Wind Energy Project, about 42 wind-power projects ranging from 6 MW to 150 MW are at different stages of development in Vietnam, for a total capacity of 3.9 GW. Last year, the Vietnam Renewable Energy Joint Stock Company completed the first phase of a 120MW wind farm in Binh Thuan Province, with 201.5 MW turbines connected to the grid so far [3].

1.4 Wind power in Indonesia

The implementation of wind energy technology in Indonesia is still low. The total wind power generation installed in Indonesia is around 1.6 MW in non-commercial scales. The implementation of isolated wind energy systems typically in remote area/location or islands, and they are frequently installed as part of development or research project. Several area along the shore of northern and southern part of Java Island, eastern part of Madura island, southern and northern part of Sulawesi Island, and some part of Nusa Tenggara islands, have applied wind turbine for generating electricity. Most of them are implemented in stand-alone system and hybrid systems but the quantity and quality still need to be improved.

The biggest capacity of wind turbine unit installed in Indonesia at the moment is 100kW, which installed by the Ministry of Energy and Mineral Resources (MEMR) at Sukabumi-West Java and Selayar-South Sulawesi. However, up to present, the largest wind power generation facility is installed at Nusa Penida-Bali, with the total capacity of 735 kW. This on-grid wind power generation facility is collaboration between the local government of Klungkung, Bali, MEMR and PT. PLN (Persero). The second biggest total capacity installed of wind power is 240 kW at Sangihe-North Sulawesi. This grid connection system installation is also the collaboration between the MEMR and PT. PLN (Persero), where the wind power generations are directly supply the PLN's grid [4].

2. Wind energy potency in Indonesia

2.1 Measurement campaign

One of the most important issues in developing wind energy is the measurement. An exact measurement method had to be conducted in order to have a valid data on wind energy, especially for the wind speed. This is a very crucial for the technology selection that will be used to generate the electricity.

Indonesia had the potency of wind energy resources. The MEMR predicted that the total capacity of wind energy in the country is around 9.29 GW. However, the total capacity installed for wind power generation is only 1.6MW, and mostly are for research purposes.

The wind data in Indonesia are obtained from various wind measurement such as from the National

Meteorological Agency (BMKG) and by in-situ measurement done by National Institute of Aeronautics and Space (LAPAN), Winrock International USA, Wind Guard Germany in cooperation with the Local Governments), Soluziona in cooperation with the MEMR, NipSA_Spain and other relevant institutions at several areas in Indonesia. However, there are still locations that have not yet been accessed because of its remote places, the big amount of isolated locations and financial limitations. For those locations, the cooperation's with related institutions and private sector are required. For data quality improvement, the number of measurement are extended by using more reliable equipment and direct measurement at the selection location,

Based on the data collected, about 166 sites in Indonesia had been measured for the wind energy potency [3]. And the result showed that 35 sites have good potential wind energy, with the average of annual wind speed is above 6 m/s. In addition, about 34 sites also have sufficient wind energy to be developed; with the average of annual wind speed is ranging between 4 – 5 m/s.

The measurement of wind energy in Indonesia had been conducted more than 15 years ago. Most of it was conducted by LAPAN [4].

Table 2. Indonesia wind data summary.

Resources potential	Wind Speed at 50 m , (m/s)	Wind Power dencity, at 50 m , ($W/m^{2)}$	Number of sites	Provinces
Marginal	3,0 – 4,0	< 75	84	Maluku, Papua, Sumba, Mentawai, Bengkulu, Jambi, East and West Nusa Tenggara, South and North Sulawesi North Sumatera, Central Java, Maluku, DIY, Lampung, Kalimantan
Fair	4,0 – 5,0	75 - 150	34	Central and East Java, DIY, Bali, Bengkulu, East and West Nusa Tenggara, South and North Sulawesi
good	> 5,0	> 150	35	Banten, DKI, Central and West Java, DIY, East and West Nusa Tenggara, South and North Sulawesi, Maluku

Source: LAPAN Wind Data .

2.2 Wind resources assessment (WRA)

Wind Resources Assessment (WRA) is performed in order to predict the wind energy potency in a region. It requirs the wind climate secondary data for meso-scale and primary data for the micro-scale (secondary data from statistical down-scaling is possible if the weather satellite data as the primary data is not available). WRA in this study were performed in the category of micro-scale, where the analysed area is 20 km magnitude of reference point.

WHyPGen project had conducted WRA in 11 sites, using both data from the satellite and field visit survey. The WRA are located in 7 provinces, and the total area assessed is around 9,936.53 km2 area. By using a 55 m diameter of wind turbine (or about 750 kW capacity), the simulation resulted that the wind energy in these locations can generate electricity about 2.745 GW or about 55.184 GWh/year. The following location data has been carried out in the wind resources assessment presented in Table 3 [5].

Table 3. Site of wind resources assessment summary.

Site	V_{ave}	Weibul Parameter		WPD
	m/s	C(m/s)	k	W/m^2
Baron DIY	5,8	6,6	2,34	202
Lebak - Banten	5,5	6,2	2,07	185
Nusa Penida - Bali	4,9	5,5	1,97	137
Oelbubuk NTT	6,7	7,8	2,33	334
Bantul DIY	4,1	4,6	1,7	99
Sukabumi West Java	6,6	7,4	2,54	272
Purworejo Central Java	5.32	5.9	1.52	250
Garut West Java *)	6.6	7.5	3.29	248
Sidrap South Sulawesi *)	7.04	7.9	2.06	395
Jeneponto South Sulawesi *)	8.11	9.3	2.73	511
Selayar South Sulawesi	4.0	4.5	1.86	83

*) data source: 3TIER.

2.3. Wind map

WRA is one of the main programs that has been performed continuously, in cooperated with several institutions, both national and international to produce wind map for several regions in Indonesia based on the available data from monitored locations and existing topographical data and information, using certain extrapolating technique. And Indonesia wind map/atlases is is should be developed soon. In that reference, the commitment from any relevant institutions is needed.

The following figure (Fig. 2) shows the wind energy potency in Indonesia assessed through the data satellite from 3TIER. The potential location is coloured graduating from yellow to dark brown. It shows that wind energy resources are available in the south coast of Java Island, eastern part of Indonesia (NTT, Maluku) and south part of Sulawesi Island. Nevertheless, some part of Sumatera, Kalimantan and Papua, especially the islands, also had resources for wind energy which can be utilized to generate electricity, especially for rural and remote places where still have very limited access to electricity facility.

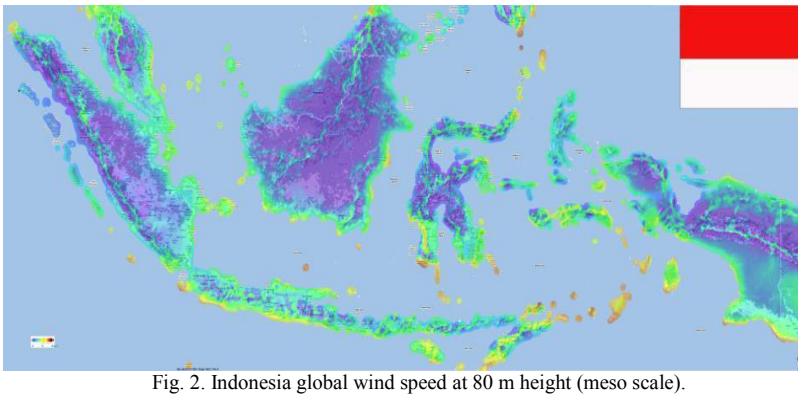


Fig. 2. Indonesia global wind speed at 80 m height (meso scale).
Source: 3TIER.

2.4. Wind farm potential sites

The study conducted on the potential sites showed the possibilities on the wind power development, with the capacity of medium to large scale. The summary data on wind study result is presented in the following table.

Table 4. The summary of wind farm potential site.

Site	V_{ave} m/s	Weibul Parameter		Wind Power Density W/m^2	Calculation Height (m)	Calculation Resolution (m)
		C(m/s)	k			
Baron, DIY	6.13	6.29	2.24	245	50	150
Lebak, Banten	5.58	6.3	2.06	198	50	150
Nusa Penida, Bali	2.73	3.1	1.66	30	20	130
Oelbubuk, NTT	6.1	6.9	1.6	301	30	160
Bantul, DIY	4	4.7	1.87	91	50	130
Sukabumi, West Java	6.27	7.1	2.08	272	50	180
Purworejo, Central Java	5.16	5.7	1.5	231	60	150
Garut, West Java	6.57	7.4	2.89	268	50	100
Sidrap, South Sulawesi	6.43	7.3	2.05	320	50	100
Jeneponto, South Sulawesi	7.96	9.0	2.51	491	50	100
Selayar, South Sulawesi	4.6	5.2	1.83	143	24	100

3. Opportunity and challenges

3.1. Opportunity of wind energy in Indonesia

The limited availability of the fossil fuel forces the country to search alternative for producing energy and electricity. Moreover, the high subsidies of the fuel had become a great issue and crisis that need to be solved immediately [3]. This is the very main idea of a great opportunity in developing such renewable energy like wind energy.

Moreover, some locations in Indonesia, especially remote places, still remain untouched with electricity. In location where the wind potency is available, wind power generation will become a good solution.

Wind energy is a renewable energy which its existence is free in the universe. This mean, no fuel cost will be needed to generate electricity from the wind energy. Even more, the absence of combustion process in the wind power generation will produce less emission. This made the wind power generation as one of the green and environment friendly solutions from the power generation sectors.

The released of government policies and regulation related to renewable energy is a very good sign for the development and utilization of wind energy in Indonesia.

The law number 30 year 2007 on the Energy had obliged the national and local government to increase the utilization of new and renewable energy (article 2, paragraph 2). This means that the utilization of wind energy as a power generation also being encouraged.

Furthermore, the released of the Law number 30 year 2009 on the Electricity had reinforced the previous law on the new and renewable energy utilization that the primary energy utilization had to be prioritized through the new and renewable energy resources (article 6, paragraph 2).

Those two regulations had clearly stated the Government of Indonesia is support the utilization of renewable energy. The opportunity is widely open to utilize the wind energy as power generation.

3.2. Challenges of wind energy development in Indonesia

The need of reliable wind measurement data and assessment is crucial. WHyPGen Project will support this activity as a support for national development of wind energy.

The 11 assessed wind energy locations will be promoted to both government and private sector to have a capacity building on the wind energy potency in Indonesia. This should answer the hesitation of the availability of wind energy in the country. Furthermore, the wind mapping and assessment will continue to be conducted to other identified potential locations.

At the other hand, the availability of financial support is required for the wind energy development in the

country. The relatively high investment of the technology still becomes one of the challenges for wind power market development in Indonesia. Facilitation of such green incentives or subsidies to the wind energy is required in order to attract the project developer and investors to involve in the wind energy business and lead the development of the market.

A specific and conducive regulation, especially for the support of financial and wind energy investment is still required. One of the crucial policies required for wind energy is the pricing policy, in which this policy will serve as a guarantee from the government to the investor that the electricity produced by the wind energy will be paid in a competitive price. Though the released of the MEMR Regulation No. 4 year 2012 on pricing policy for new and renewable energy and excess power had regulate the electricity price produced by the wind energy, however, compare to the fossil fuel, it still not to count to be competitive to attract the interest of the project developer and investors.

Others constraint identified is that the lack of promotional and advocacy programs related to wind power generation development. This related to the lack of success story on the wind energy business. Therefore, all the relevant stakeholders must work hand-in hand to develop a success wind power generation. Support and commitment are the most required issues from the government to have a wind energy developed in the country [5]. Looking into neighbouring country experiences, like Philippine, Indonesia can take the best practice and lessons learned to be implemented in the country.

4. Wind hybrid power generation

From the technological perspective, the wind power generation can be both implemented in a standalone system (off-grid) or in a grid connected system (on-grid). For remote places where the grid rarely available, the off-grid system can be a good alternatives to provide electricity in the location.

However, wind energy is very much fluctuates. In some season the wind can blow very hard while in the other it can barely blowing. To overcome this fluctuating characteristic of wind energy, a hybrid system can be applied, especially for the off-grid application [6].

Wind power generation can be combined with other power generation such as solar module (pv) or even diesel engine. The main function of generating sets is to take over the supply of electricity during the low of wind speed.

The existing application of wind power generation in the country is the one at Pandan Simo, Yogyakarta. Total of 17.5kW of solar power generation (PV) had been hybridize with a total of 60kW wind turbine. This application had been successfully implemented and supported the electrification of the surrounding community. Not only supporting the electricity for public lighting, and water pump for irrigation and fishery, the application also very much useful as a power generation in producing ice for the fisherman in preserving their catch [6].

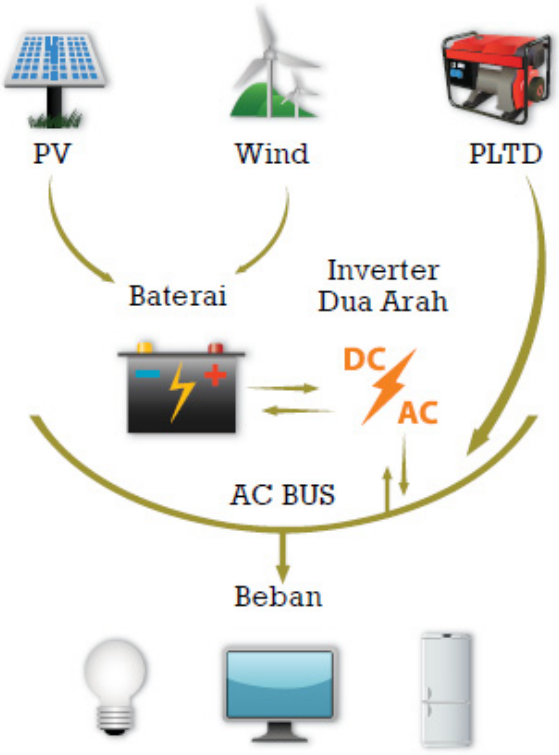


Fig. 3. Wind-solar-diesel hybrid scheme (off-grid systems).

Fig. 4. Wind-solar-diesel hybrid systems at East Nusa Tenggara.

5. Result and discussion

From the assessment and data collected on wind energy potency in Indonesia, seems that in several location, Indonesia had a very good potency of wind energy, even for a commercial scale of wind power generation. However, this potency still remains undeveloped due to several barriers such as confident level, financial and policy support. Supporting activities, such as wind energy measurement and assessment need to be conducted to have a new updated wind map of Indonesia.

For remote places, especially islands, the utilization of wind energy resources need to be promoted and encouraged. The availability of wind energy in certain seasons can be very much useful and contribute to the electrification of the area. Wind hybrid system application will be a good solution for such area in community based or to support public facilitation.

Unfortunately, this kind of opportunity still not fully supported with solid financing and policy initiatives. Therefore**,** participation and commitment from all the relevant stakeholders, from government and private sector, investor and project developers are required**.**

6. Conclusion

To promote a more sustain energy in the country, commitment to develop and utilized the renewable energy, including wind energy, should be put in place. Good coordination between respective stakeholders is also required. Without commitment, the wind energy will remain potency without being developed and utilized

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